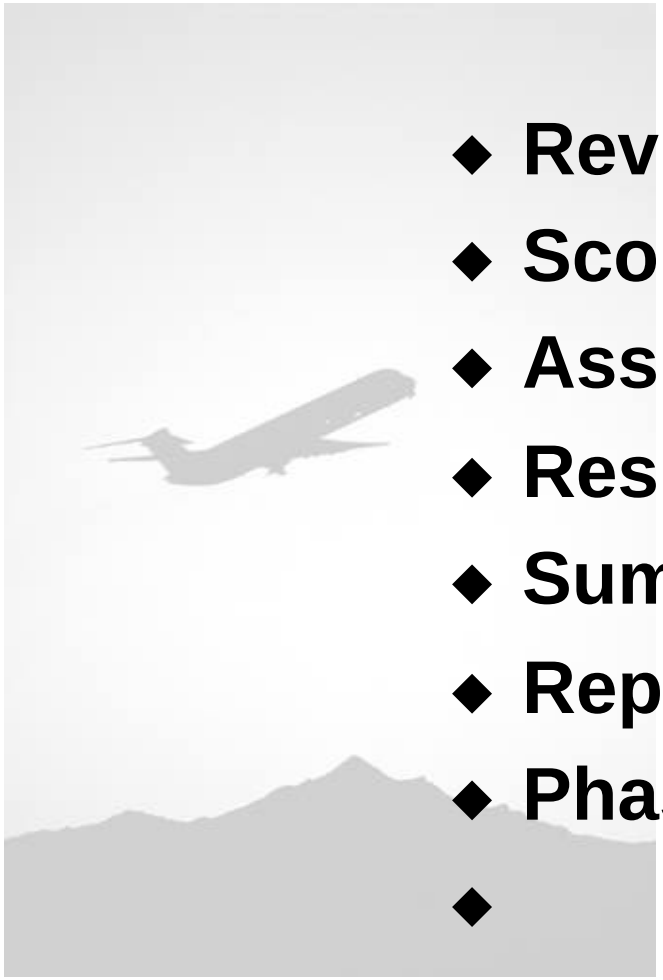
CNS/ATM Enhancements to Reduce Aircraft Emissions

May 6, 1998

ASD-430/ACT-520

SETA/CSSI

Outline



- Review Study Objective
- Scope of Analysis
- Assumptions
- Results
- Summary of Rio Briefing
- Report and Documentation
- Phase II
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Study Objective

- Develop preliminary estimates of fuel savings and resulting emission reductions (NOx, CO, and HC) from CNS/ATM enhancements in the U.S.
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- Results should identify the upper bound of savings that could be achieved in the best case situation.
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- Results of analysis to be presented at the FAA briefing at the ICAO World-wide CNS/ATM Systems Implementation Conference in May.

Scope of Analysis

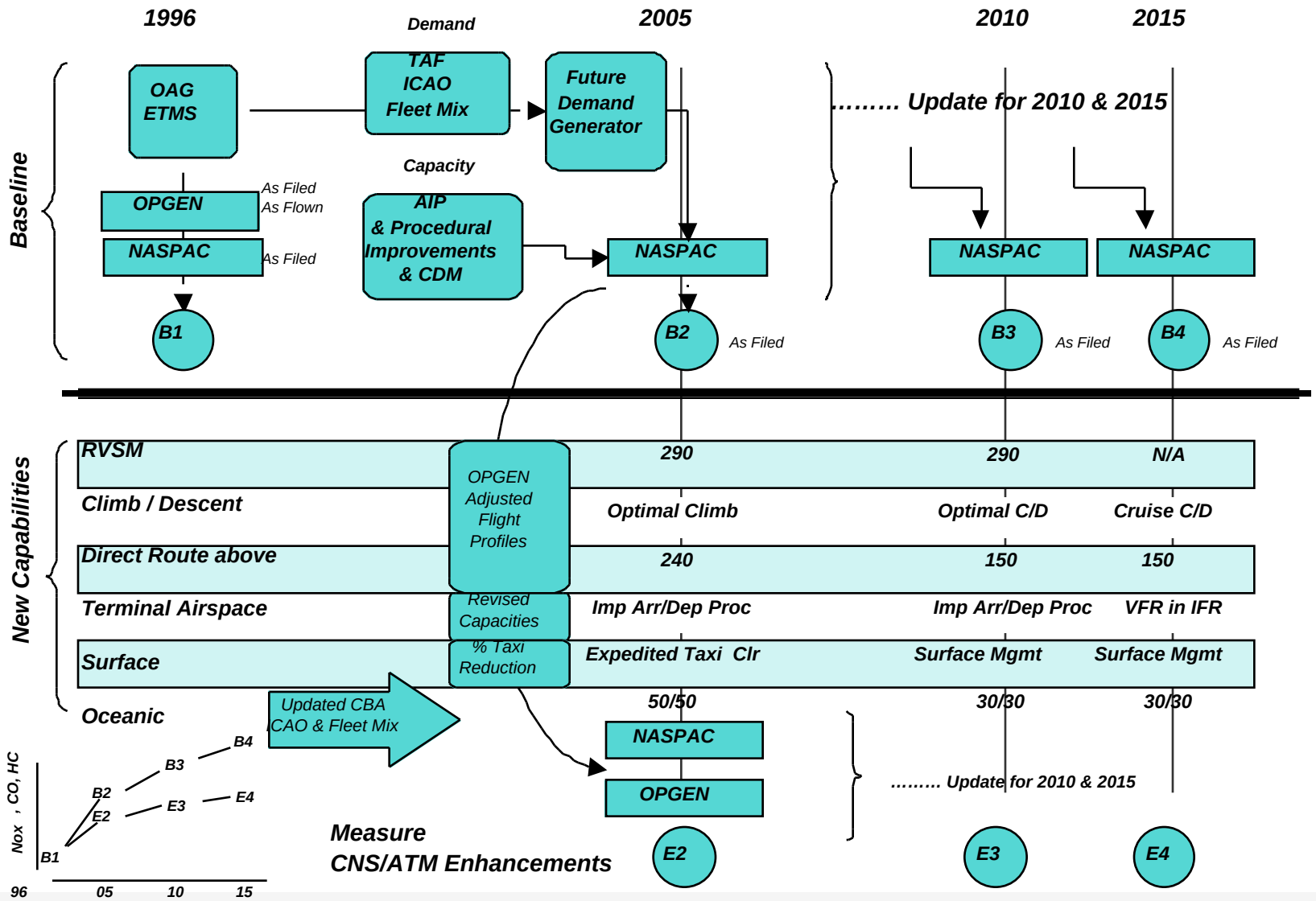
- **Period of evaluation is 1996-2015 and will cover planned CNS/ATM improvements in:**
  - **US controlled Oceanic airspace**
  - **CONUS En route and terminal airspace**
  - **Surface operations**

- **Use the Concept of Operations and preliminary NAS Architecture V3.0 to provide the time-frame for the implementation of the planned CNS/ATM capabilities**

Baseline and Future NAS Scenarios

Baseline	Projected Traffic Growth and Fleet Mix w/no Modernization			
Future NAS Scenarios		**2005**	**2010**	**2015**
Key Technologies		**CPDLC ADS-B A/A PFast/TMA SC Initial Conflict Probe SMA ITWS**	**Limited NEXCOM WAAS/LAAS A-Fast/WV STARS P3I SMS ADS-B Ground Stations**	**Full NEXCOM Full Conflict Probe New TFM DSS Tools**
New Capabilities				
	RVSM Climb/Descent Direct Route Terminal Airspace Surface Oceanic Separation	**FL290 Optimal Climb Above FL240 Imp Arr/Dep Proc Expedited Taxi Clearance 50/50**	**FL290 Optimal Climb/Descent Above 150 Imp Arr/Dep Proc Enhanced Surface Mgmt 30/30**	**N/A Cruise Climb/Descent Above 150 VFR in IFR Enhanced Surface Mgmt 30/30**

Modeling Scenarios



Assumptions

- **Base year for US aviation fuel consumption is 1996.**
- **Fuel and emission calculations cover only IFR flight plan traffic.**
- **Current airspace structure will be modified as appropriate to accommodate CNS/ATM enhancements.**
- **Fuel-emission conversion algorithms provided by FAA/AEE, ICAO, and NASA/Boeing were used to calculate emissions for ground, climb/descent, and cruise phases of flight.**

Sources of Data

- **Enhanced Traffic Management System & Official Airline Guide**
  - **Baseline traffic operations**
- **ICAO**
  - **Pacific and N. Atlantic traffic forecasts**
  - **Oceanic & domestic fleet mix projections**
- **FAA/APO, ATA, ICAO, & NASA**
  - **Traffic forecasts**
  - **Fleet mix projections**
-

Sources of Data (cont.)

- FAA/ASC
  - Planned runways
  - Airport capacity data
- FAA/ASD
  - NAS Architecture V3.0 Draft plans and schedule
  - Performance metrics, investment analyses, and cost-benefit studies
- AEE/NASA/Boeing
  - Aircraft performance data
  - Fuel-emission conversion algorithms

Fleet Mix

Class	Type	1996	2005	2010	2015
20-40 seats					
1	DHC6	64	108	131	155
1	DHC8	144	244	296	349
1	D328	37	63	76	90
1	Embr120	237	402	488	576
1	J31	87	148	180	212
1	J32	83	141	171	202
1	J41	39	66	80	95
>40 seats					
1	ATP	12	36	48	61
1	ATR-42	100	299	400	506
1	ATR-72	51	153	204	258
1	CV-580	18	54	72	91
1	CRJ	36	108	144	182
1	DHC7	29	87	116	147
1	F27	14	42	56	71
Total Class 1		**951**	**1950**	**2462**	**2994**
2	BAE146	41	47	52	57
2	A320	109	187	267	306
2	DC8	102	119	131	143
2	DC9	454	408	328	328
2	737-100	11	0	0	0
2	727/100-200	680	147	0	0
2	707/720	2	2	3	3
2	737-200	312	90	5	0
2	737-500	160	459	600	658
2	737-400	94	123	135	147
2	737-300	482	561	618	673
2	MD-81/82/83/87/88	615	775	915	1010
2	MD-90	11	13	14	16
2	F-100	130	151	166	181
2	F-28	70	81	90	97
Total Class 2		**3273**	**3163**	**3324**	**3618**

Class	Type	1996	2005	2010	2015
3	757	660	1803	2294	2592
3	A310	41	79	99	115
Total Class 3		**701**	**1882**	**2393**	**2707**
4	747-SP	4	0	0	0
4	L1011	101	49	53	53
4	DC10	176	205	175	175
4	767	224	483	611	854
4	777	12	159	218	251
4	A300	73	225	298	431
Total Class 4		**591**	**1121**	**1355**	**1764**
5	IL86				
5	MD11	55	70	93	117
5	747-300				
5	747-400	47	91	126	161
5	747-100	59	50	50	50
5	747-200	62	60	53	52
Total Class 5		**223**	**271**	**322**	**380**
6	XX		39	80	133
Total Class 6		**0**	**39**	**80**	**133**
7	747-SR	0	19	92	144
Total (7)		**0**	**19**	**92**	**144**
TOTAL Class 2-7		**4787**	**6494**	**7566**	**8745**

Class	# of Seats	Class	# of Seats
1	0-80	5	301-400
2	81-150	6	401-500
3	151-210	7	501-600
4	211-300		

- ***Compiled from ICAO Worldwide Fleet Forecasts.***
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- ***1996 Baseline year obtained from LMI ASAC/ NASA model***
-
- ***Updated to reflect APO Classes of Aircraft***
-
- ***Reviewed by study team***

Capabilities as Modeled

NASPAC simulation inputs reflect future airport capacity increases

- **Physical improvements, such as new airports and new runways**
- **Procedural improvements, such as two parallel and one converging arrival streams**
- **CNS/ATM improvements, such as CTAS, ITWS, and ADS-B/CDTI-enabled approaches**

Reductions in taxi time

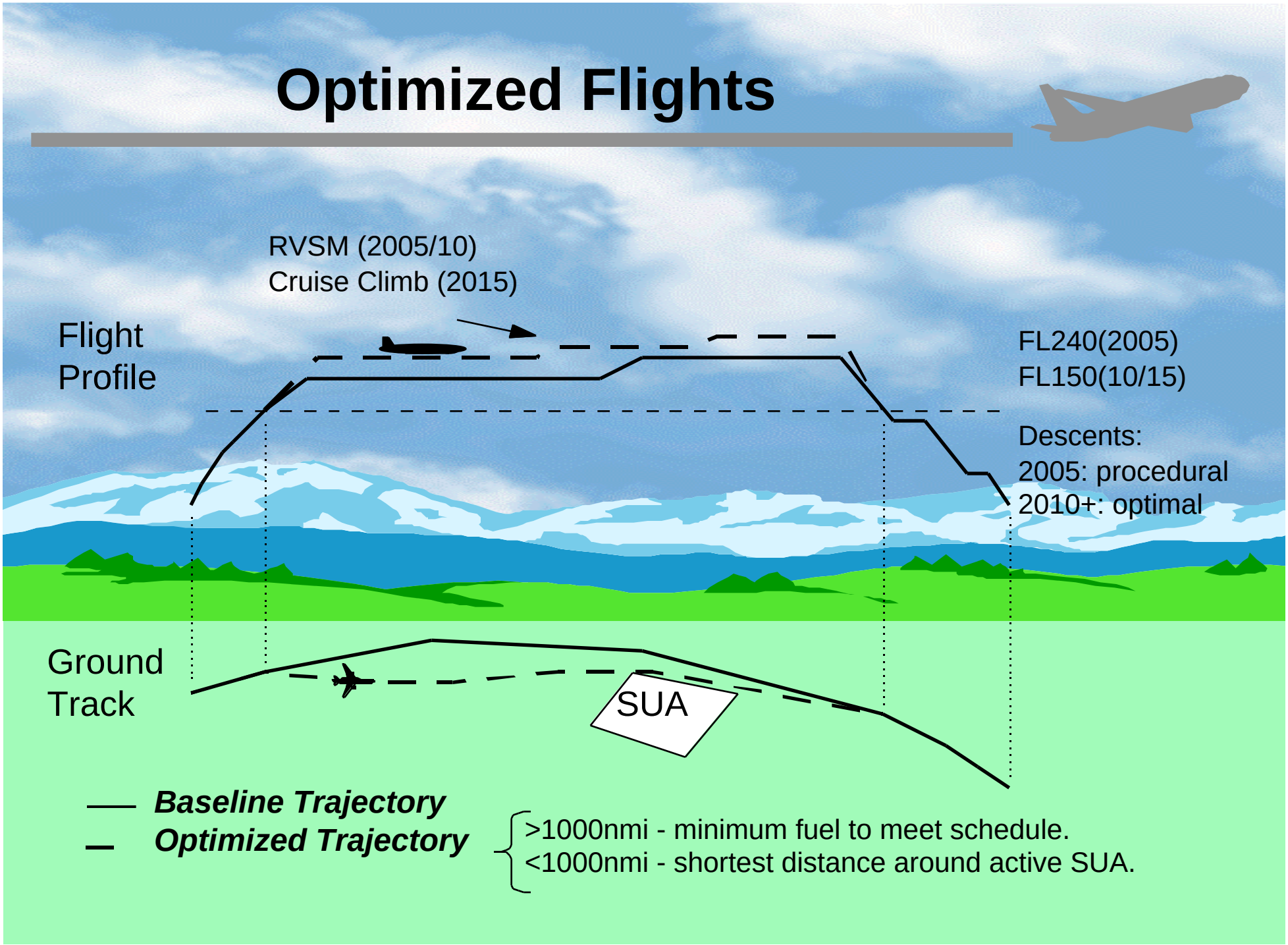
Effects of improvements on airport capacity were calculated and entered into NASPAC simulations

NASPAC

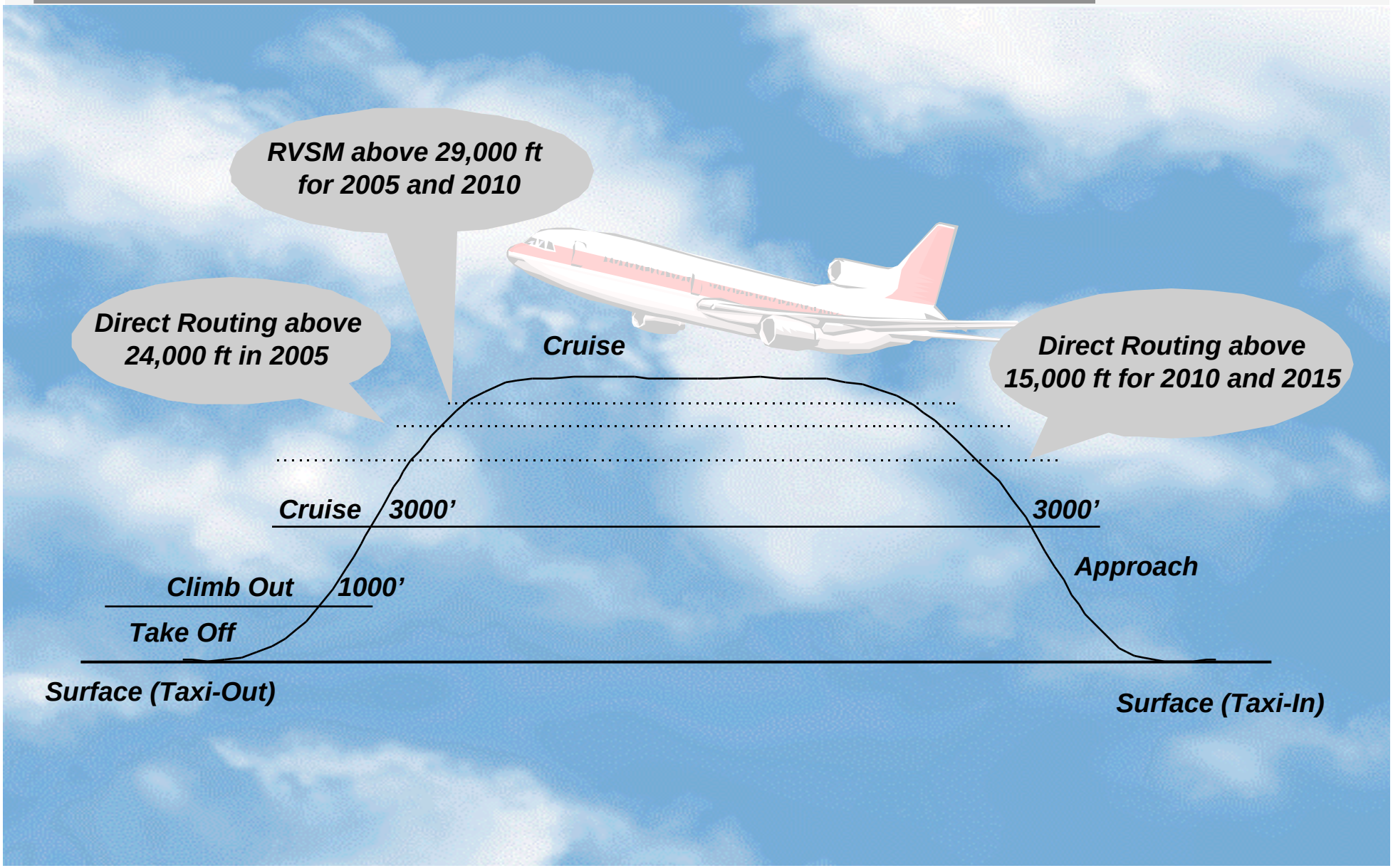
Baseline cases included only physical and procedural improvements

CNS/ATM cases included CNS/ATM improvements, along with new procedures that will depend on them

Optimized Flights



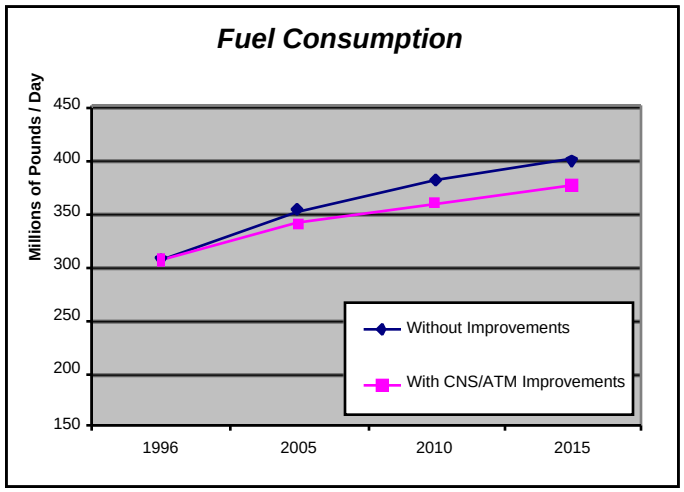
Emission - Phases of Flight

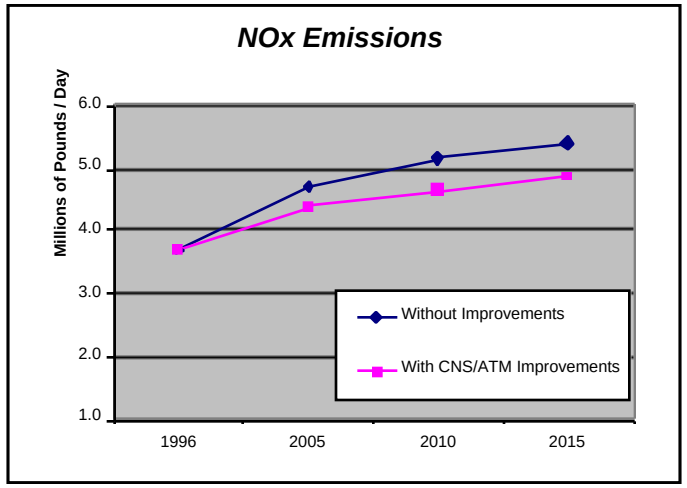


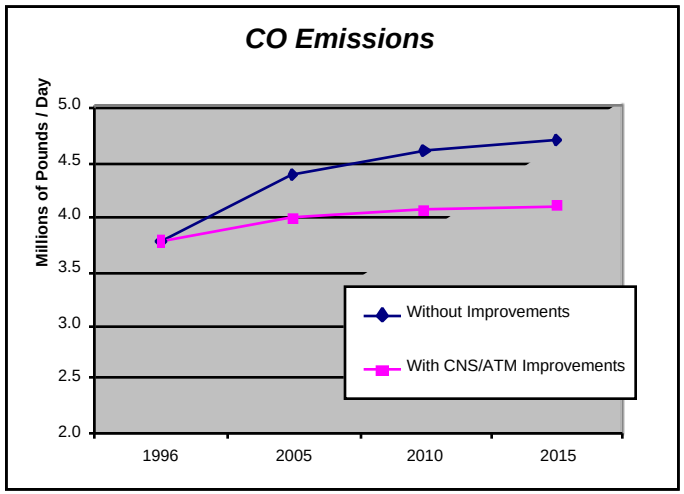
CONUS & Surface Results *(1,000 lbs. / Day)*

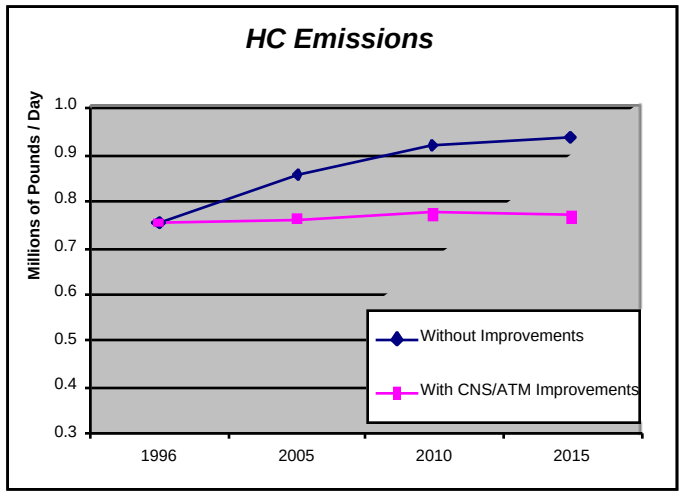
		Baseline Case				CNS/ATM Improvements							
Year	**Mode**	**Fuel**	**NOx**	**CO**	**HC**	**Fuel**		**NOx**		**CO**		**HC**	
1996	**Total**	**305,805**	**3,712**	**3,772**	**754**								
	Above 3000	253,195	3,100	2,926	569								
	Below 3000	33,380	547	200	19								
	Surface	19,231	65	647	166								
2005	**Total**	**351,964**	**4,708**	**4,373**	**854**	**339,240**	**-3.6%**	**4,377**	**-7.0%**	**3,974**	**-9.1%**	**758**	**-11.2%**
	Above 3000	292,604	3,935	3,431	657	280,656		3,609		3,041		563	
	Below 3000	38,346	702	195	19	37,824		698		191		18	
	Surface	21,013	72	747	177	20,759		71		742		176	
2010	**Total**	**380,176**	**5,126**	**4,607**	**919**	**359,263**	**-5.5%**	**4,636**	**-9.5%**	**4,059**	**-11.9%**	**773**	**-15.9%**
	Above 3000	317,224	4,292	3,595	713	297,424		3,810		3,074		572	
	Below 3000	40,414	757	194	19	40,041		752		192		18	
	Surface	22,538	77	817	188	21,797		75		793		183	
2015	**Total**	**399,157**	**5,399**	**4,706**	**937**	**374,953**	**-6.1%**	**4,867**	**-9.9%**	**4,109**	**-12.7%**	**768**	**-18.0%**
	Above 3000	333,192	4,513	3,666	727	310,633		3,996		3,110		568	
	Below 3000	42,756	806	198	19	42,132		795		195		19	
	Surface	23,209	80	842	191	22,188		76		804		182	

Key Metrics

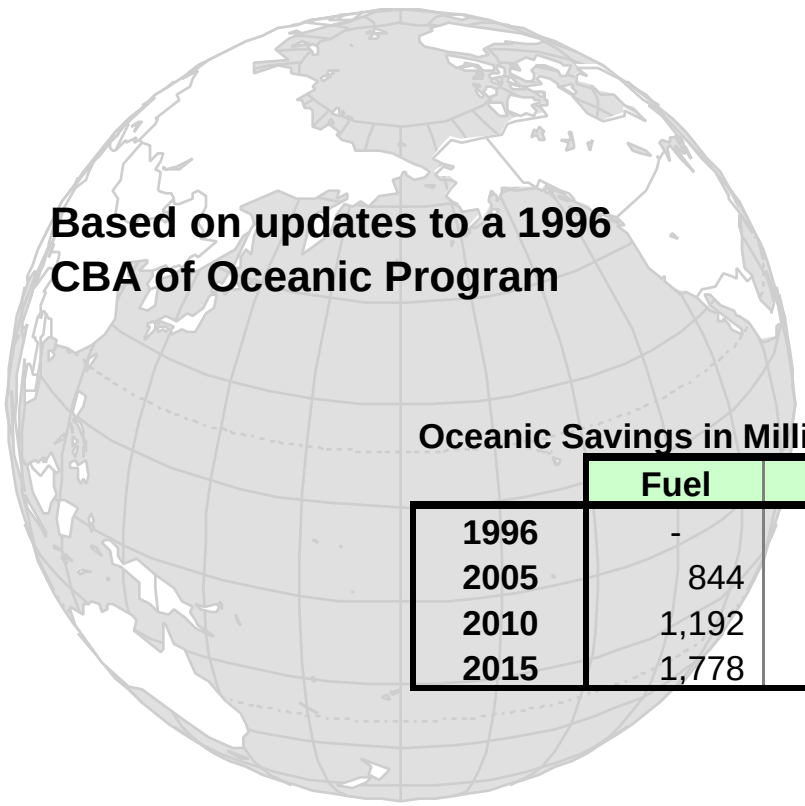

Fuel Consumption
Millions of Pounds / Day
450
400
350
300
250
200
150
1996
2005
2010
2015
Without Improvements
With CNS/ATM Improvements


NOx Emissions
Millions of Pounds / Day
6.0
5.0
4.0
3.0
2.0
1.0
1996
2005
2010
2015
Without Improvements
With CNS/ATM Improvements


CO Emissions
Millions of Pounds / Day
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1996
2005
2010
2015
Without Improvements
With CNS/ATM Improvements


HC Emissions
Millions of Pounds / Day
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1996
2005
2010
2015
Without Improvements
With CNS/ATM Improvements

Oceanic - Update of Previous Analysis



Based on updates to a 1996 CBA of Oceanic Program

Incorporated ICAO Traffic Forecasts ~ 4.4% annual growth

Fleet Mix adjusted to conform to worldwide estimates

Oceanic Savings in Millions of Pounds per Year

	Fuel	NOx	CO	HC
1996	-	-	-	-
2005	844	10.7	1.0	0.4
2010	1,192	15.1	1.4	0.6
2015	1,778	22.5	2.0	0.9

Annual Savings by 2015

- **Annualized Simulation results for Nov 12th adjusted for:**
  - **Day of Week**
  - **Seasonal Variation**
  -
  -
  -

Millions of Pounds/year

	Fuel	NOx	CO	HC
Savings	8,481	187	209	59
% Reduction	-6.1%	-9.9%	-12.7%	-18.0%

- **Annual Oceanic Savings**

Millions of Pounds/year

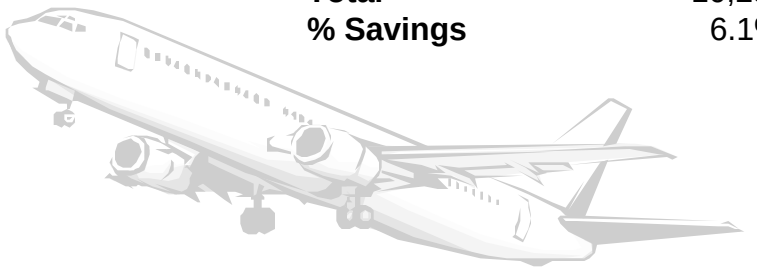
Oceanic	1,778	23	2.0	0.9

Summary of Rio Briefing

- **Comparison of the two scenarios indicates the CNS/ATM enhancements to the NAS have a potential annual fuel savings of over 10 billion pounds by the year 2015, which represents a savings of 6% over what would have been achieved without NAS modernization. The phase of flight above 3,000 feet, which offers capability for more fuel efficient flight operations accounts for 94% of the savings, with remaining savings occurring on the surface and up to 3,000 ft. These fuel savings translate to an annual reduction in emissions of over 209 million pounds of NOx, 211 million pounds of CO, and 59 million pounds of HC, representing savings of over 9%, 12%, and 18% respectively.**

Annual Savings in Millions of Pounds

	Fuel	NOx	CO	HC
Above 3,000	9,683	204.3	197.1	56.7
Below 3,000	219	4.0	1.1	0.1
Surface	358	1.2	13.2	3.1
Total	10,259	209.5	211.4	59.9
% Savings	6.1%	9.9%	12.7%	18.0%



Remaining Schedule

Study Team Activity	Start Date	Finish Dat
Kickoff meeting	1/9	1/9
Status meeting	1/28	1/28
Finalize and coordinate study plan	1/29	2/18
Fuel burn simulation & analysis		
· Oceanic analysis	2/12	3/6
· Surface analysis	1/29	3/10
· Terminal/En Route	1/29	3/17
Emission calculations	2/26	3/24
MITRE Review Results	3/11	3/11
Integrate and review analysis	3/25	3/30
Brief analysis and findings	3/31	3/31
Preliminary Results	4/1	4/1
Additional Analyses	4/2	4/10
Coordinate and integrate into Rio briefing	4/3	4/17
Executive Report for Rio	4/6	4/17
Prepare Draft Report	4/20	6/26
Review	6/29	7/31
Final report	8/3	8/31

Report & Documentation

Follow-on Activities

- Compare to 1992 Data
-
- Future Briefings
  - NASA Workgroup (Cleveland)
  - FAA & Eurocontrol (December)
-
- Expand on Economics & Sensitivity Analysis
-
- Application to other Operational Analyses